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APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A
FILING DATE.

APPLICATION NUMBER: 60/427,133

FILING DATE: November 18, 2002

RELATED PCT APPLICATION NUMBER: PCT/US03/36558

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET.

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

11002 U.S. PRO
60742/133

11/18/02

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 Additional inventors are being named on the _____ separately numbered sheets attached hereto.

TITLE OF THE INVENTION (280 characters max)

DE-SCALING AND CORROSION INHIBITING COMPOSITION

Direct all correspondence to:

CORRESPONDENCE ADDRESS

 Customer NumberPlace Customer Number
Bar Code Label here

OR

Type Customer Number here

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ENCLOSED APPLICATION PARTS (check all that apply)

 Specification Number of Pages
(INCLUDING DRAWINGS)

17

CD(s), Number

 Drawing(s) Number of sheets

Other (specify)

 Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)

 Applicant claims small entity status. See 37 CFR 1.27. A check or money order is enclosed to cover the filing fees The Commissioner is hereby authorized to charge filing fees
or credit any overpayment to Deposit Account Number:

01-0035

FILING FEE
AMOUNT (\$)

\$160.00

 Payment by credit card. Form PTO-2038 is attached.The invention was made by an agency of the United States Government or under a contract with an agency of the United States
Government. No. Yes, the name of the U.S. Government agency and the Government contract number are: _____

Respectfully submitted,

SIGNATURE

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Date November 18, 2002

REGISTRATION NO.

25, 928

(if appropriate)

Docket Number:

205,971

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C., 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C., 20231.

INDUSTRIAL CHEMICAL CLEANING SOLUTION

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Corrosion Control Engineering Unit

ABSTRACT:

A feasible and efficient industrial cleaning solution (Industrial De-scaling Solution) had been prepared and evaluated under the industrial conditions which include the variation of flow rate, temperature (bulk and interfacial) and heat flux. The discovered inhibitor acts to block both the anodic and cathodic sites. The performance of the prepared de-scaling solution is competitive with the imported solutions. This solution was successfully tested and applied to clean the industrial equipments for the Jordanian army.

INTRODUCTION:

Equipments in power plants, chemical and petrochemical plants, paper mills, sugar plants, pipelines, air conditioner in large buildings and many other industrial environments are subject to the formation of scale, either by circulating water or by process compounds. This includes all types of heat exchangers, boilers, vessels, reactors, piping and other equipments. Precipitated solids reduce the heat transfer, may cause tube failure due to over heating or may eventually results in plugging or fouling of equipments. To prevent industrial process interference, cleaning of the metal surfaces is therefore required.

The water - formed precipitates (in the Middle East) are generally inorganic in nature, especially that formed in hot closed systems, e.g. in steam generators or heat exchangers. Common deposits found in the Middle East factories include iron oxide (magnetite, hematite) sulfide, alkaline earth carbonates, sulfates and silicates.

Hydrochloric acid is widely used for chemical cleaning of structural steel made heat transfer and piping systems. Hydrochloric acid forms soluble products when dissolves calcium or magnesium carbonates and sulfates. It is cheap in price and produced locally in Saudi Arabia. Hydrochloric acid does not dissolve sulfates or silicates. Therefore, other chemicals should be blended with the hydrochloric acid.

Hydrochloric acid is highly corrosive media. If copper salts are present in the scale, it will dissolve and

re-precipitate on iron surface causing sever localized corrosion. Descaling processes are usually performed at 50C°.

The dissolution of scale is an exothermic process, viz. the interfacial temperature of the metal is different than the bulk temperature of the cleaning solution.

The purpose of this work is to prepare a locally made industrial cleaning solution, which is effective for removing scales and oxides from the industrial installations with no hard or corrosion to the equipments surfaces. This cleaning solution is competitive with the imported solutions.

The invented inhibitor is non-toxic and having high inhibition efficiency under isothermal and heat transfer conditions for various values of flow rates.

It should be kept in mind that the cleaned equipments have to be neutralized immediately and protected (passivated).

If Saudi Aramco approves this work, I will provide a formula of non-toxic inhibitors (had been studied and evaluated) to passivate the surfaces of the cleaned equipments.

The prepared cleaning solution is not recommended for water tube boilers and stainless steel made equipments.

COMPOSITION OF THE PREPARED INDUSTRIAL DE-SCALING SOLUTION

Intensive tow years of research work had been focused to prepare a relevant, feasible and efficient industrial cleaning solution having the following formula:

- 1- 8% hydrochloric acid: effective for removing most calcium, magnesium and iron oxides.
- 2- 1.5%hydrofluoric acid; aids in the removal of silicates containing scales. (The mixture of (1) & (2) accelerates the dissolution of many hard and complex scales)
- 3- 2% citric acid and 2% EDTA are added as chelating agents to dissolve iron oxide deposits and deposits containing copper oxides. Sulfate containing deposits will be dissolved as well.
- 4- 0.1 g/l neutral surfactant, ordinary detergent was used.
- 5- Copper complexing agent: 100-PPM Theo urea. When copper oxides are present in the deposit, it may dissolve and then plate out as metallic copper causing sever pitting corrosion of the industrial equipments and piping systems. This reagent will keep the copper in soluble state.
- 6- 80-PPM Acrydine orange (AO) is invented as non-toxic inhibitor with high performance to block the anodic and cathodic sites on the structural steel under the industrial conditions.

Note: Tetraethylenhexamine, produced locally in Iraq, (150 PPM + proper wetting agent was studied by the inventor and a patent was issued for that scientific work - Patent No. 2246 in 03 - 01 - 1990 Iraq- Baghdad)

EXPERIMENTAL WORK

Mild steel specimens (5×2.5 cm) cut from a single sheet of cold rolled 1020 steel were used. The specimens were polished under running tap water using silicon carbide emery paper (100, 400 and 600 grit), washed with distilled water, degreased with benzene and weighed by electronic balance (Mettler A J 100). The specimens were fully immersed in 500 cm^3 of the cleaning solution with and without inhibitor (AO). Duration of the weight loss experiments was 8 hrs. At the end of the test, the specimens were withdrawn, rinsed with water, dried and reweighed.

Percentage inhibitor efficiency was calculated from the equation:

$$I \% = \{ (W_u - W_l) / W_u \} * 100 \quad (1)$$

Potentiostatic polarization was carried out for both inhibited and uninhibited solutions under isothermal conditions at 303, 313 and 323 K and under controlled conditions of flow, viz. 600, 1000 and 1400 R.P.M.

Table 1 Values of Reynolds Number Studied

<u>R.P.M</u>	<u>ω (rad./sec)</u>	<u>Bulk Temperature K</u>		
		<u>303</u>	<u>313</u>	<u>323</u>
600	62.8	20207	38195	44247
1000	104.7	50346	63659	73747
1400	146.6	70486	89125	103247

The above experiments were repeated with an iron electrode sustaining heat of 60-kW/m^2 . Potentials were measured with a saturated calomel electrode through a luggin probe beneath the rotating disc electrode, thus minimizing IR_o drops and providing no significant disturbance to the hydrodynamic, thermal and diffusion boundary layers⁽¹⁾.

Potentiostatic polarization studies were made using a potentiostat (Model 553 - AMEL - Italy). The iron electrode was polarized from -900 mV to -100 mV (vs. saturated calomel electrode) at a sweep rate of 20 mV/min.

For the heat transfer set of experiments, a potential of -1000 mV was applied until a steady-state heat flux was attained as indicated by the constant temperature reading from the thermocouples. Then the full polarization was carried-out as under isothermal conditions.

The corrosion rates were determined using Stern and Geary method⁽²⁾ (linear - polarization technique). The dimensions and the experimental set-up are shown in Figures 1 and 2. The design features and the method of the interfacial phenomena calculations are explained elsewhere⁽³⁾.

Results and discussion

Introduction

An intensive work had been done to determine the relevant economical and workable composition of this industrial chemical cleaning solution.

Acrydine Orange (AO) was selected as inhibitor for this solution because:

- 1- AO has fast and direct protonation when added to acid solutions. The protonation process is a charge transfer process, viz. flow independent.
- 2- The inhibitor molecules bound strongly on the metal surface.
- 3- The free flat aromatic rings, with surface area of 38 A^2 are bound in a plane parallel to the metal surface such that the position of the positively charged nitrogen ring is close to the predominant negatively charged electric layer on the metal surface⁽⁴⁾. The highly inhibitive characteristics of the inhibitor confirm the planier adsorption arrangement rather than inclined orientation or other different orientation associated with different surface coverage as the temperature (bulk or interfacial) changes.

The inhibitive characteristics of AO

1- Static Conditions:

Weight loss experiments were carried out in the prepared chemical cleaning solution under static conditions for various inhibitor concentrations and different temperatures

Table 2. The Corrosion Rate (C.R.) and Inhibition Efficiency (I%) at various Temperatures and Inhibitor Concentration (AO) in the Prepared Cleaning Solution, (g/ cm². hr)

Inhibitor Concentration PPM	C.R. (g/ cm ² . hr)			I%		
				Temperature, K		
	303	313	323	303	313	323
0	1.411E-3	3.258E-3	7.855E-3	0	0	0
1	8.017E-4	1.440E-3	4.780E-3	43.2	55.7	39.1
2	6.496E-4	1.144E-3	3.750E-3	57.9	64.5	55.0
5	3.450E-4	7.503E-4	1.798E-3	75.6	76.73	77.1
10	1.860E-4	5.900E-4	1.566E-3	82.0	81.9	80.1
15	2.594E-4	4.505E-4	1.324E-3	87.2	86.2	83.1
20	9.950E-4	2.370E-4	9.690E-4	92.9	92.7	87.7
40	9.950E-5	1.613E-4	6.367E-4	94.8	95.1	91.7
60	7.387E-5	1.200E-4	4.840E-4	95.9	96.3	94.2
80	6.820E-5	1.990E-4	3.182E-4	96.8	96.8	96.0
100	7.524E-5	1.475E-4	5.084E-4	96.8	96.8	96.0
150	6.785E-5	1.002E-4	4.099E-4	96.8	96.8	96.0
200	8.018E-5	1.354E-4	2.370E-4	96.8	96.8	96.0

*E = Exponential

1-1: Inhibition Mechanism:

The degree of coverage of the metal surface was calculated from the expression:

$$\Phi = 1 - CR_I / CR_u \quad (2)$$

The fraction Φ of the metal surface is protected while the bare fraction of the metal surface ($1 - \Phi$) reacts⁽³⁾. The binding curves of AO inhibitor are shown in Fig's. (3 – 5). Out of these figures, it can be concluded that the mechanism of the inhibition follows tow processes:

Process (a)- by which AO molecules bound strongly on the metal surface by chemisorption's process. The free flat aromatic rings, with surface area of $38\text{A}^{\circ 2}$, are bound in plane parallel to the metal surface such that the position of nitrogen ring is close to the predominant negatively charged electric layer on the metal surface⁽⁴⁾. The highly inhibitive characteristics of AO shown in Table 1 confirm the planner adsorption arrangements, rather than inclined orientation associated with different coverage, for the range of temperatures studied.

Process (b)- is a weak interaction process fall into two distinct portions, i.e. one of high slope corresponding to process (a) "Portion AB in Figures (3-5) and other of low slope portion CD. The inflected form of the binding curve suggests that process (b) of weaker binding part of AO is cooperative. So that the binding of one AO cat ion facilitates the binding of the next, particularly as process (b) appears at high concentration of inhibitor in which self aggregation occurs and can be explained by the concept of stacking which can be described as the binding of legend molecules already bound on an external surface of the adsorbed mono layer (by electrostatic forces). The legends interact mutually in a direction perpendicular to their aromatic planes, so that they pile upon each other like a stack of coin⁽⁴⁾. The slope of the first portion A-B, in Figures (3-5), decreased with the increase in temperature, which can be attributed to the decrease in the number of the binding sites. The slope of the portion C-D is constant for inhibitor concentration of 60 PPM and above.

Figures (3-5) fit the Temkin adsorption isotherm which is expressed by the following Equations:

$$\Phi = (-R T / \alpha q_0) \ln A \cdot C \quad (3)$$

$$\text{Or } \Phi = (-R T / \alpha q_0) \ln A - (-R T / \alpha q_0) \ln C \quad (4)$$

$$\text{Viz. } \Phi = m \log C + \text{Constant} \quad (5)$$

These results are in agreement with the results obtained by Riggs and Hurd⁽⁶⁾ for corrosion inhibition of steel in 2N HCl for the temperature range (313-356 K) using amine base inhibitor (N-Hexa decyl pridinium chloride)

2- Performance of the Inhibitor (AO) under Controlled Conditions of Heat and Mass Transfer

2.1 Cathodic Region:

The effect of fluid flow, bulk temperature and heat transfer on the cathodic current density at a given cathodic potential of 0.1 V below the corrosion potential are shown in Tables 3, 4 and 5.

Table 3. The Cathodic Current Density mA/cm² for Uninhibited Chemical Cleaning Solution I_{c,u} and Inhibited Solution I_{c,i} and the Inhibition Efficiency I% under Isothermal Conditions. (Inhibitor Concentration 60 PPM)

Temperature, K

<u>RPM</u>	<u>303</u>			<u>313</u>			<u>323</u>		
	I _{c,u}	I _{c,i}	I%	I _{c,u}	I _{c,i}	I%	I _{c,u}	I _{c,i}	I%
0	15	1.6	89	39	5.5	86	57	8.8	85
600	4.6	0.5	89	14	1.6	88.6	36	3.3	90.8
1000	4.6	0.46	90	14	1.6	88.6	34	3.0	91
1400	4.8	0.51	89.4	15	1.7	88.7	34	3.5	89.7

Table 4. The Cathodic Current Density, mA/cm^2 , of Uninhibited Chemical Cleaning Solution Under 60 kW/m^2 Heat transfer (The Interfacial temperatures are Bracketed).

<u>Bulk Temperature, K</u>	<u>303</u>	<u>313</u>	<u>323</u>
<u>RPM</u>			
600	8 (322.7)	19 (330.5)	40 (339.9)
1000	7.3 (315.9)	17 (324.3)	39 (333.7)
1400	6.5 (312.3)	16 (321.6)	37 (331.4)

Table 5. The Cathodic Current Density $I_{c,L}$, mA/cm^2 , for Inhibited Chemical Cleaning Solution, under Heat Flux of 60 kW/m^2 . I% is the Inhibitor Efficiency. Interfacial Temperature values are same as in Table 4.

<u>Bulk Temperature, K</u>	<u>303</u>	<u>313</u>	<u>323</u>			
<u>RPM</u>	$I_{c,I}$	I%	$I_{c,I}$			
600	0.65	92	2.3	88	4.2	89.5
1000	0.60	92	1.9	89	3.2	91.8
1400	0.58	91.1	1.7	89.4	2.8	92.4

The above Tables show that the cathodic current density values are flow independent while the increase in temperature (bulk or interfacial) has a significant effect in stimulating the cathodic process. This confirms the activation energy control of the cathodic reaction of hydrogen as the predominant reaction as well as the lack of mass transfer effect on the adsorption processes of the inhibitor (equation 3).

The increase in temperature (bulk or interfacial) has no significant effect on the inhibition efficiency, viz. the increase in temperature has no effect on the orientation of the adsorbed molecules as well as their geometry.

The high inhibition efficiency values are attributed to the ability of the inhibitor to block the cathodic areas on the metal surface, leading to high reduction in hydrogen evolution.

The lack of flow, bulk temperature, interfacial temperature and heat transfer on the inhibition efficiency is attributed to the fast and direct protonation of the inhibitor when added to the acid solution. The protonation process is a charge transfer process, viz. activation controlled; therefore the adsorption process was flow independent.

AO showed high performance in blocking the anodic sites beside the catodic sites as shown in the data presented in Tables 6, 7 and 8 for both isothermal and heat transfer conditions.

Table 6 The anodic Current Density, mA/cm², for uninhibited Chemical Cleaning Solution, I_{a,U}, Inhibited Solution, I_{a,I}, and the Inhibitor Efficiency, I%, Under Isothermal Conditions

<u>RPM</u>	<u>Temperature, K</u>								
	303		313		323				
	I _{a,U}	I _{a,I}	I%	I _{a,U}	I _{a,I}	I%	I _{a,U}	I _{a,I}	I%
0	29	1.8	94	46	2.5	97	97	16	83.5
600	7	1.3	81	14	2.3	93.6	40	5.7	86
1000	6.8	1.3	81	15	2.0	86.7	36	4.8	87
1400	7.1	1.3	81.7	15	2.7	82	38	3.5	91

Table 7 The anodic Current Density, mA/cm², for uninhibited Chemical Cleaning Solution under 60 kW/m² Heat Transfer Rate. (The Interfacial Temperatures are bracketed)

<u>Bulk Temperature, K</u>	<u>303</u>	<u>313</u>	<u>323</u>
<u>RPM</u>			
600	13 (322.7)	23 (330.5)	63 (339.9)
1000	12 (315.9)	23 (324.3)	58 (333.7)
1400	11 (312.3)	20 (321)	48 (331)

Table 8 The Anodic Current Density I_{a,I}, mA/cm², for Inhibited Chemical Cleaning Solution and the Inhibitor Efficiency, I%, under 60 kW/m², Heat Transfer Rate.

<u>Bulk Temperature, K</u>	<u>303</u>			<u>313</u>		
<u>RPM</u>	I _{a,I}	I%	I _{a,I}	I%	I _{a,I}	I%
600	1.8	86	4.1	82	12	81
1000	1.6	87	3.7	84	7.8	87
1400	1.4	87	3.3	83	6.0	87

Tables 6, 7 and 8 were read off the polarization diagrams at 0.1 V above the corrosion potentials.

The inhibition of the anodic sites (tables 6-8) and cathodic sites (tables 3-5) confirm the mixed effect of the inhibitor as presented schematically in Figure 6.

The corrosion rates under isothermal and heat transfer conditions for both inhibited and uninhibited solutions were measured using resistance polarization technique. The inhibition efficiency values are reported in table 9.

Table 9 The Efficiency of the Inhibitor at the Corrosion Potential for both Isothermal ($I_{corr,I}$) and Heat Transfer conditions ($I_{corr,H}$)

<u>Bulk Temperature, K</u>	<u>303</u>	<u>313</u>		<u>323</u>	
<u>RPM</u>	$I_{corr,I}$	$I_{corr,H}$	$I_{corr,I}$	$I_{corr,H}$	$I_{corr,I}$
600	95	92	96	88	94
1000	96	86	94	94	95
1400	94	90	94	92	94

CONCLUSION

- 1- The prepared chemical cleaning solution is efficient in removing the industrial scales and oxide with no harm or corrosion to the industrial equipments and piping systems.
- 2- The presence of copper in the scale has no side effect in stimulating the pitting corrosion to the steel equipments.
- 3- Acridine Orange (AO) acts effectively in blocking both the anodic and cathodic sites on the metal surface with high corrosion protection to the equipments. ACRIDINE ORANGE IS NON- TOXIC CHEMICAL

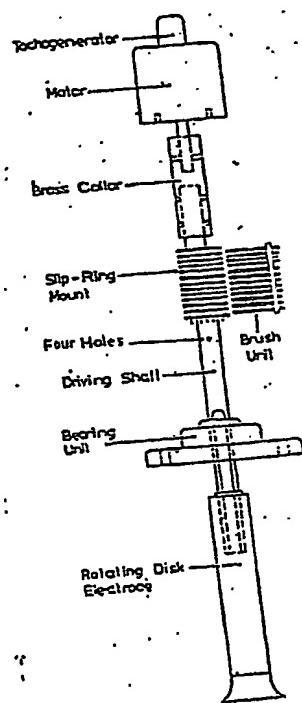
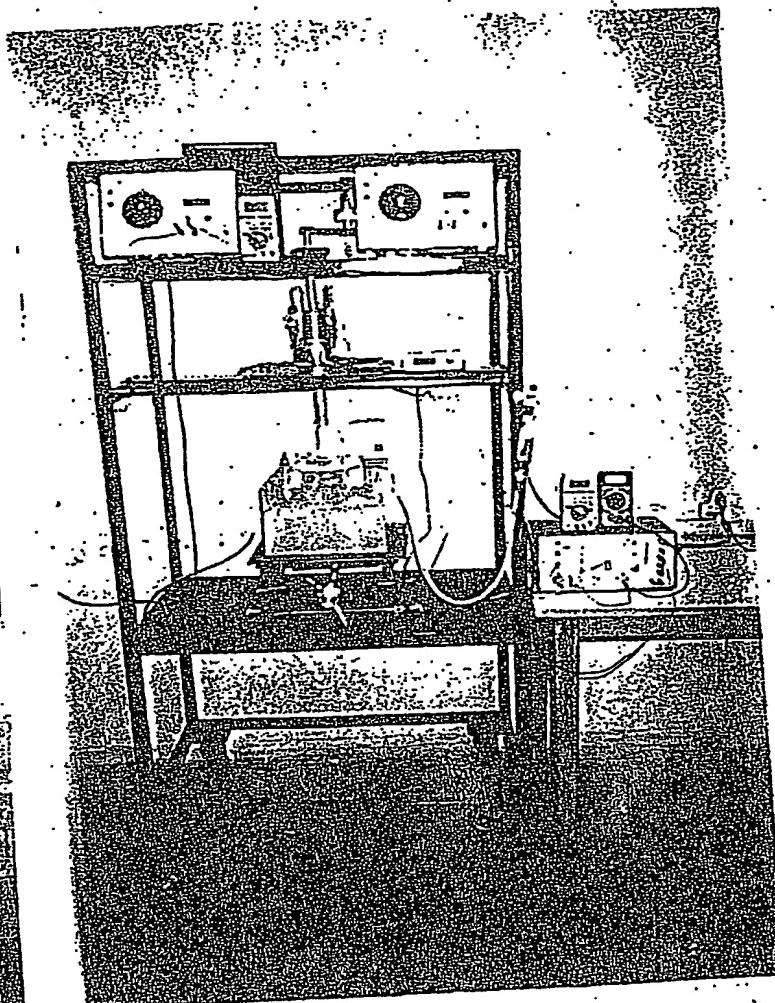
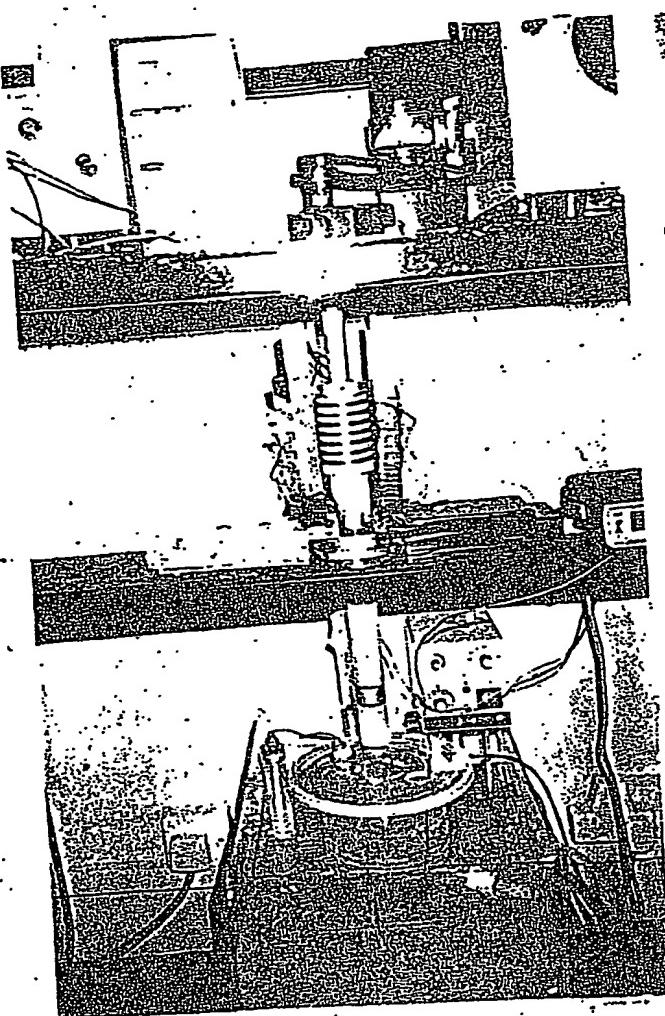


Fig. 1- Experimental Set-up

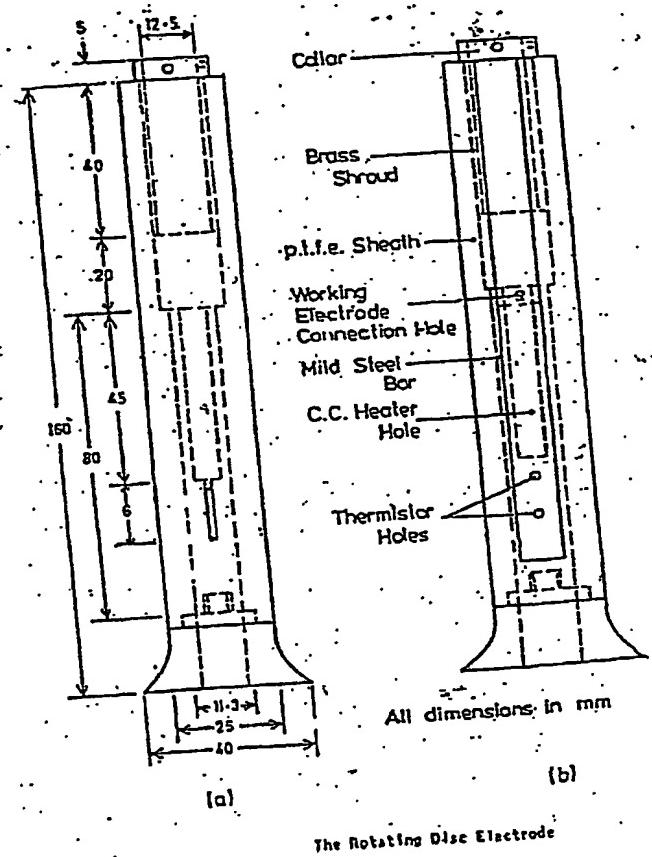
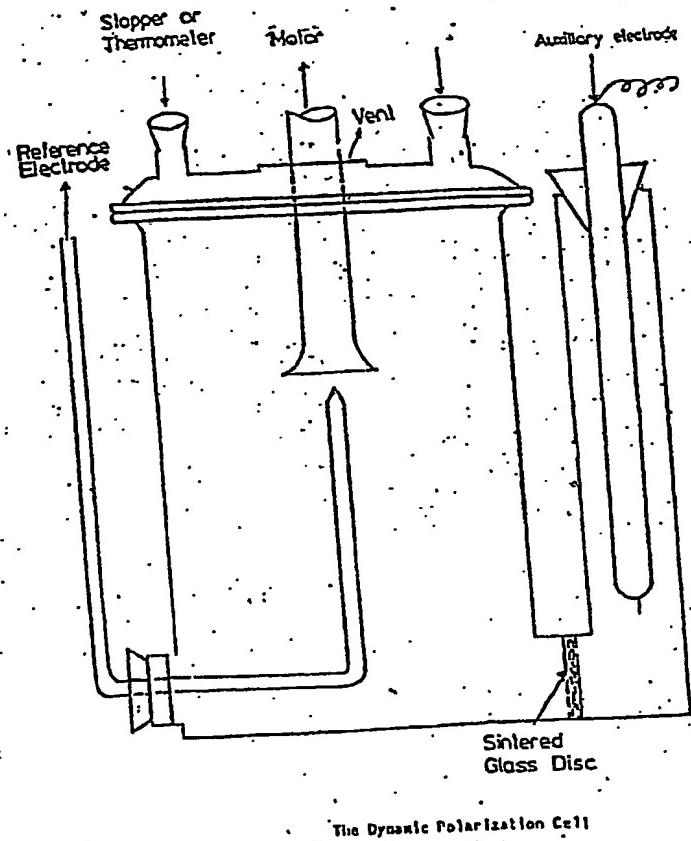


Fig. 2- The Polarization Cell and the Rotating Electrode.

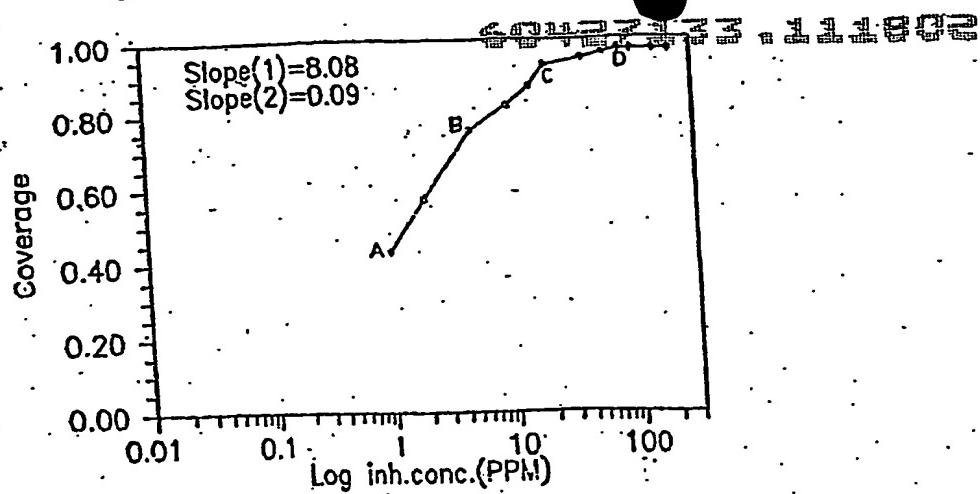


Fig. 3- Adsorption Isotherm of AO at 30 °C

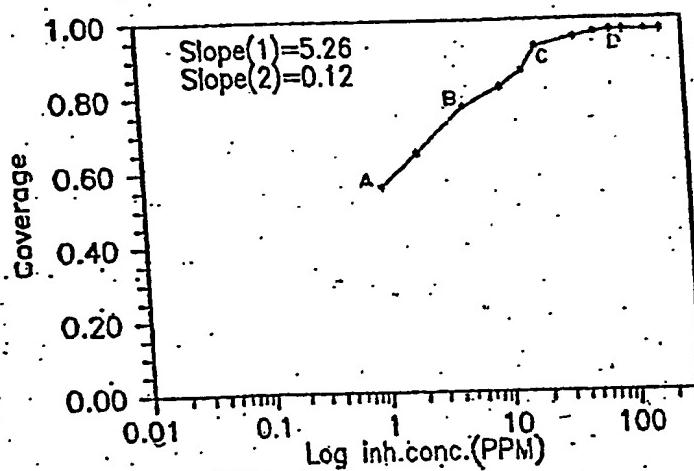


Fig. 4- Adsorption isotherm of AO at 40 °C

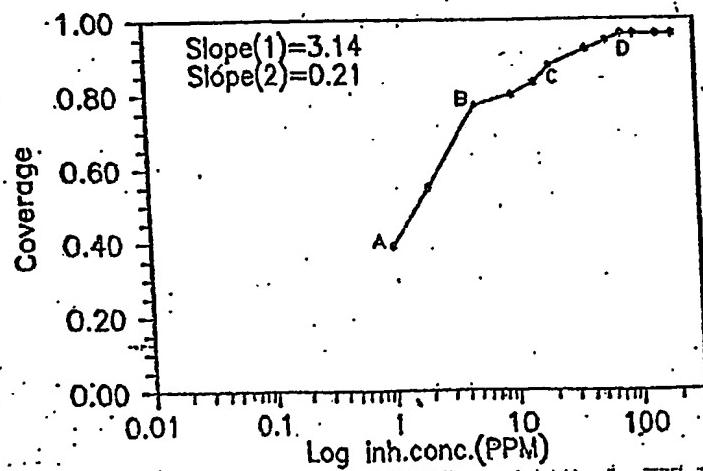


Fig. 5- Adsorption isotherm of AO at 50 °C

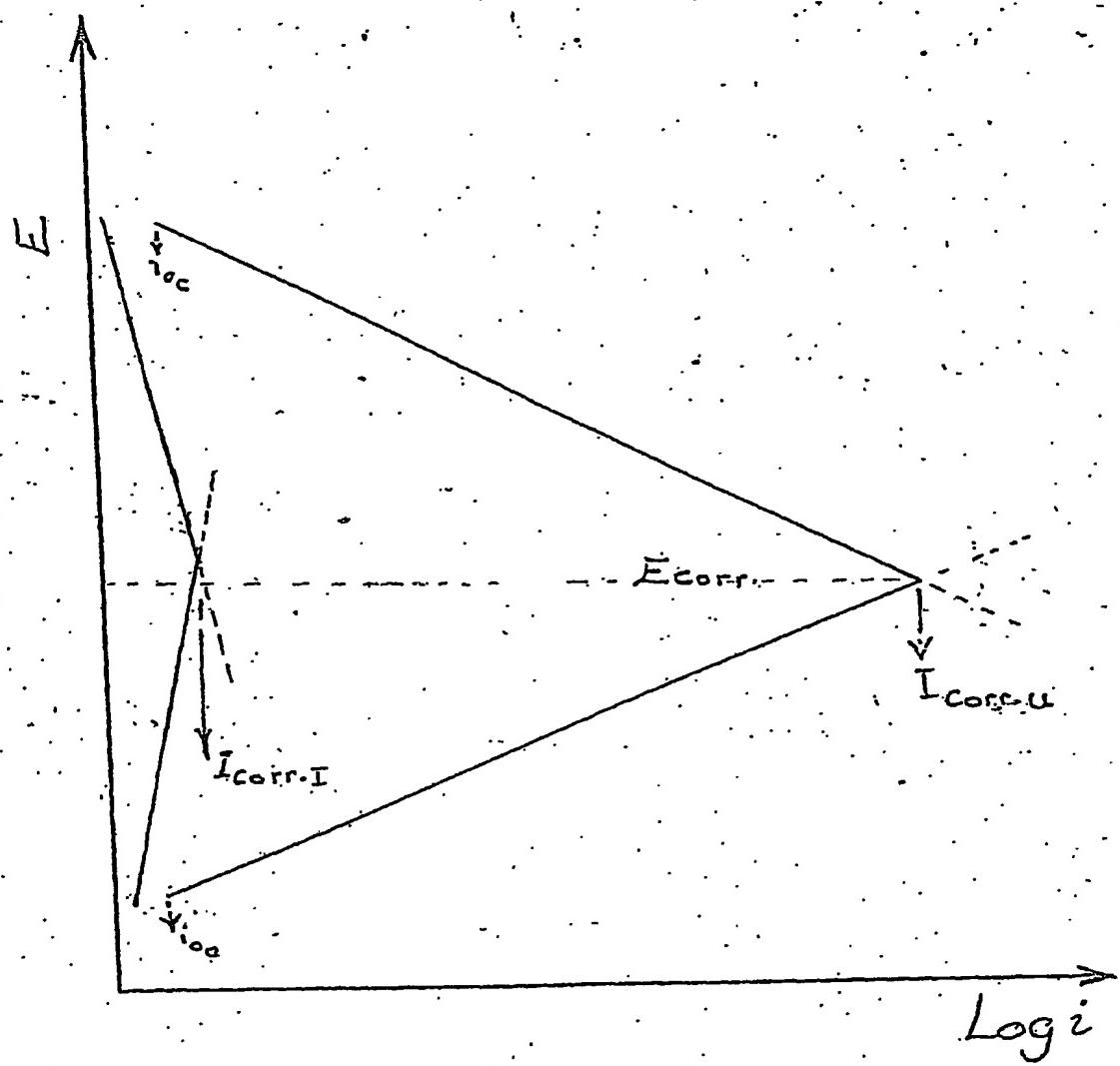


Fig. 6. Schematic Diagram Showing the Mixed Effect of the Inhibitor AO

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in hot 95% ethanol using phenolphthalein as indicator.

Acid Yellow 9. See 4-aminoazobenzene-3,4'-disulfonic acid.

acifluorfen, sodium salt. (Blazer).

Use: Post emergent herbicide for soybeans, peanuts, and rice.

"Acitol."²⁵² TM for a series of tall oils, crude and distilled, and tall oil derivatives such as fatty acids, rosins, tall oil heads, pitch. The derivatives are usually obtained by fractional distillation.

Combustible.

Use: Adhesives; cement; intermediates; degreasing compounds; emulsifiers; flotation agents; ink vehicles; leather chemicals; lubricants; metallic soaps; oil-well drilling muds; paints and varnishes; rubber chemicals; soaps and cleaners.

"ACL."⁵⁵ TM for a series of solid, organic chlorine liberating compounds used in bleaches, cleansers, sanitizers, etc.

"Aclar."⁵⁰ TM for a series of fluorohalocarbon films.

Properties: Useful properties from -200 to +198C.

Use: In packaging applications where a transparent, vapor, and/or gas barrier is required, as in packaging of foods for astronauts. Used in electronic and electrical applications because of insulating and heat-resistant properties. Extreme chemical resistance and ability to seal make it useful as a tank lining, etc.

"A-C-M."²⁹⁹ TM for a balanced mixture of ascorbic acid (vitamin C) and citric acid.

Use: As an antioxidant that protects flavor and prevents browning of fruits exposed to air. Used in home freezing and canning of fresh fruits.

"Acofor."³⁸ TM for pale distilled tall oil fatty acids.

Properties: D 0.907 (25/25C); refr index 1.471 (20C); flash p 380F (193C). (OC), acid number 192; saponification number 194; unsaponifiable matter 2.5%; rosin acids 4.5%. Combustible.

Use: Paint and varnish; inks; soaps; disinfectants; textile oils; core oils, etc.

"Aconew."³⁸ TM for pale distilled tall oil fatty acids with low rosin acid contents.

aconite. (monkshood; wolfsbane; friar's cowl). Hazard: An antipyretic drug; an alkaloid poison.

aconitic acid. (propene-1,2,3-tricarboxylic acid). H(COOH)C(=O)C(COOH)CH2(COOH).

Properties: White to yellowish, crystalline solid; mp approximately 195C with decomposition; soluble in water and alcohol. Combustible.

Derivation: (a) By dehydration of citric acid with sulfuric acid; (b) extraction from sugar cane bagasse, *Aconitum napelius* and other natural sources.

Use: Preparation of plasticizers and wetting agents; antioxidant; organic syntheses; itaconic acid manufacture; synthetic flavors.

aconitine. (acetyl benzoyl aconine).

CAS: 302-27-2. C34H49NO11.

Hazard: A highly toxic alkaloid, an antipyretic drug; readily absorbed by skin.

acraldehyde. See acrolein.

"Acrawax."⁷³ TM for a series of synthetic waxes supplied in solid and powdered forms.

Properties: Melting range from 83 to 143C.

Use: As anti-tack agents; flattening agents in paint; lubricant and mold release agents for butyl and neoprene elastomers; adhesives; rubber; plastics.

acridine (tricyclic). CAS: 260-94-6. C13H9N.

Properties: Small, colorless needles. Soluble in alcohol, ether, or carbon disulfide; sparingly soluble in hot water. Sublimes at 100C, mp 111C, bp above 360C.

Derivation: (a) By extraction with dilute sulfuric acid from the anthracene fraction from coal tar and adding potassium dichromate. The acridine chromate precipitated is recrystallized, treated with ammonia and recrystallized. (b) Synthetic.

Hazard: Strong skin irritant.

Use: Manufacture of dyes; derivatives, especially acriflavine, proflavine; analytical reagent.

acridine orange. (N,N,N',N' -tetramethyl-3,6-acridinediamine monohydrochloride).

CAS: 65-61-2. C17H19N3.HCl.

Hazard: An *in vitro* mutagen.

Use: Selective biological stain for tumor cells, *intravital*, and causes retardation of tumor growth.

acriflavine. C14H14N3Cl. A mixture of 3,6-diamino-10-methylacridinium chloride and 3,6-diaminoacridine.

Properties: Brownish or orange, odorless, granular powder. Soluble in 3 parts of water; incompletely soluble in alcohol; nearly insoluble in ether and chloroform. The aqueous solutions fluoresce

coconut, peanut, soybean, and corn oils, some of which may be hydrogenated to solid form. They vary in degree of unsaturation, ranging from 78% for safflower to about 10% for coconut. Castor oil, though technically edible, is not usually considered in this classification, nor are medicinal oils derived from animal sources (cod liver, mineral oil, etc.).

Edman degradation. Sequential degradation of peptides beginning at the N-terminal residue based on the reaction of phenylisocyanate with the alpha-amino group of the terminal amino acid of the peptide chain.

EDTA. Abbreviation for ethylenediaminetetraacetic acid.

EDTAN. Abbreviation for ethylene diamine tetraacetonitrile.

EDTA Na₄. Abbreviation for ethylene diamine tetraacetic acid tetrasodium salt.

See tetrasodium EDTA.

edetate. See ethylene diamine tetraacetic acid (note).

effect. An evaporation-condensation unit.

See evaporation.

efflorescence. Loss of combined water molecules by a hydrate when exposed to air, resulting in partial decomposition indicated by presence of a powdery coating on the material. This commonly occurs with washing soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) which loses almost all its water constituent spontaneously.

effluent. Any gas or liquid emerging from a pipe or similar outlet; usually refers to waste products from chemical or industrial plants as stack gases or liquid mix.

egg oil. Fatty oil obtained from egg yolk by extraction with ethylene dichloride; insoluble in water, but readily forms emulsions on strong agitation.

Use: Ointments, cosmetic creams.

egg yolk.

Properties: Yellow, semi-solid mass; d 0.95; mp 22C; high cholesterol content.

Grade: Technical, edible.

Use: Baking, dairy products, mayonnaise, pharmaceuticals, soap, perfumery.

See also albumin, egg.

EHEC. Abbreviation for ethyl hydroxyethyl cellulose.

Ehrlich, Paul. (1854-1915) A native of Silesia, Ehrlich is considered the founder of the science of chemotherapy or the treatment of diseases by chemical agents. He did fundamental work on immunity which gave him the Nobel prize in medicine in 1908, and also developed the famous neoarsphenamine (salvarsan or 606) treatment for syphilis (1910) which was not improved upon until the discovery of penicillin.

Ehrlich-Sachs reaction. Formation of anils by the base-catalyzed condensation of compounds containing active methylene groups with aromatic nitroso compounds.

eicosamethyl nonasiloxane. $\text{C}_{20}\text{H}_{50}\text{O}_5\text{Si}_9$.

Properties: Inert liquid, bp 173C (5 mm), d 0.918, soluble in benzene and light hydrocarbons, slightly soluble in alcohol.

Use: Silicone fluids, foam suppressor in lube oils.

eicosane. $\text{C}_{20}\text{H}_{42}$. Most technical eicosane is a mixture of predominantly straight-chain hydrocarbons averaging 20 carbon atoms to the molecule.

Properties: (pure n-eicosane): White, crystalline solid; fp 36.7C; bp 205C (15 mm); flash p 212F (100C); refr index 1.4348 (20C); d 0.778 (at melting point); insoluble in water; soluble in ether; can be readily chlorinated. Combustible.

Grade: Pure normal (99+%), technical.

Use: Cosmetic, lubricants, plasticizers.

eicosanoic acid. See arachidic acid.

eicosanoid. Any of a number of biochemically active compounds resulting from enzymic oxidation of arachidonic acid, e.g., prostaglandins, thromboxanes, prostacyclin, and leukotrienes. As a group, they comprise what is known as the arachidonic acid cascade. They have many pharmacological and medical possibilities.

See also prostaglandin, arachidonic acid.

1-eicosanol. See arachidyl alcohol.

5,8,11,14-eicotetraenoic acid. See arachidonic acid.

Eigen, Manfred. (1927-) A German physicist who won the Nobel prize for chemistry in 1967. His research concerned the rate of hydrogen ion formation through disassociation of water. He also was concerned with enzyme control. He received his degree at the University of Gottingen.

Einhorn-Brunner reaction. Formation of substituted 1,2,4-triazoles by condensation of hydrazines or semicarbazides with diacylamines in the presence of acid catalysts.

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